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National Eutrophication Survey, Corvallis, Oreg

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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on
E. V. Spence Reservoir
Coke County
Texas
EPA Region VI
Working Paper No. 658

With the cooperation of the
Texas Water Quality Board
and the
Texas National Guard
March, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

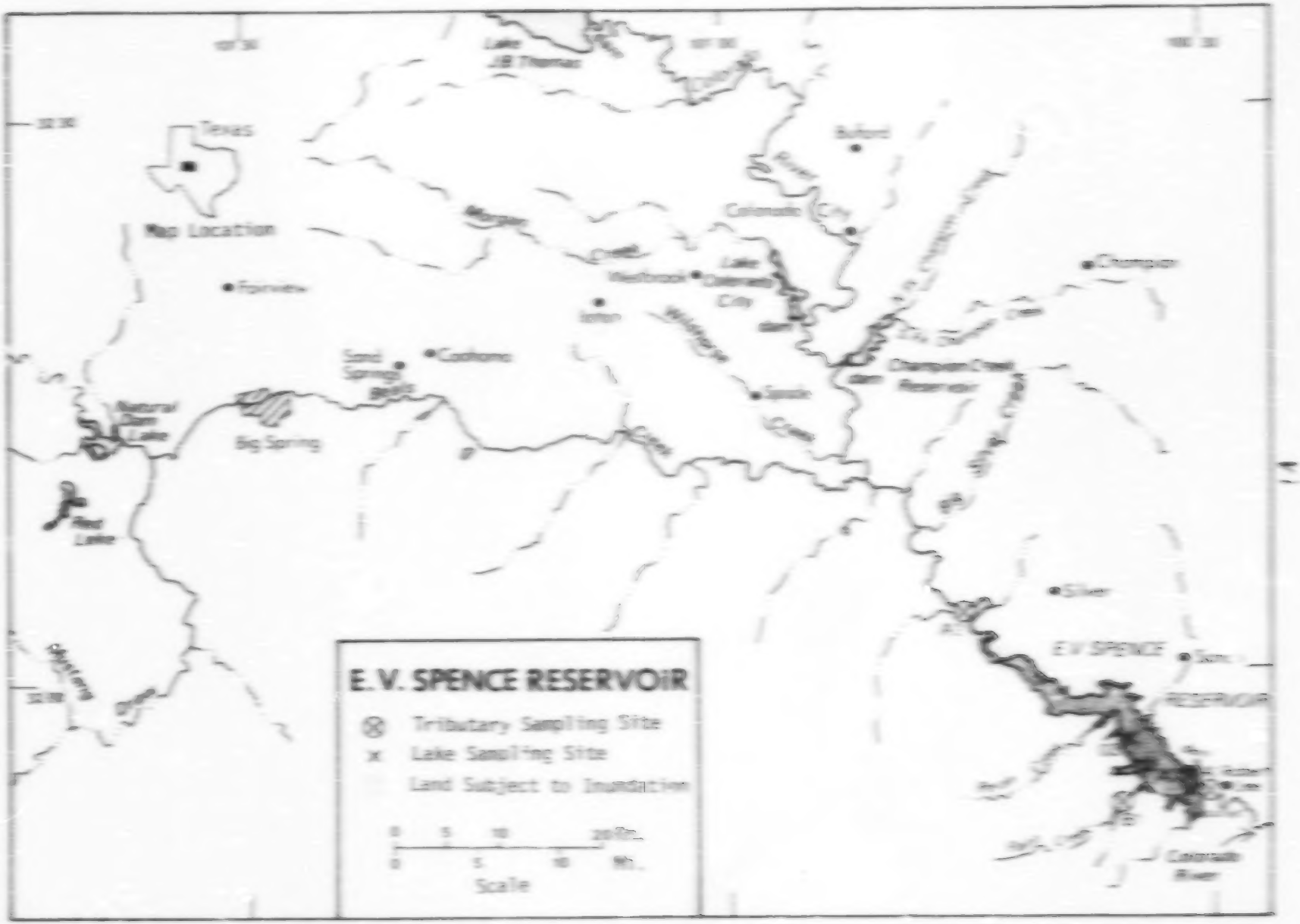
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


E.V. SPENCE RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Land Subject to Inundation
Scale
Texas
Map Location
Fairview
Colorado City
Champion
Big Spring
Coahoma
Sweetwater
Silver
E.V. SPENCE
RESERVOIR

E. V. SPENCE RESERVOIR

STORET NO. 4828

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that E. V. Spence Reservoir is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

E. V. Spence Reservoir ranked eighteenth in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Eighteen of the reservoirs had less and one had the same median total phosphorus, eight had less and two had the same median dissolved phosphorus, six had less and one had the same median inorganic nitrogen, 19 had less mean chlorophyll a, and 21 had greater mean Secchi disc transparency. Marked depression or depletion of dissolved oxygen with depth occurred at stations 1 and 2 in August.

Survey limnologists observed an algal bloom and rooted aquatic plants along the shoreline in August. Blue-green algae were dominant in the August and October phytoplankton samples.

* See Appendix A.

B. Rate-Limiting Nutrient:

Because of significant losses of phosphorus in both algal assay samples between times of collection and the beginning of the assays, the results are not representative of conditions in the reservoir at the times the samples were taken (03/04/74 and 10/29/74).

The reservoir data indicate that phosphorus was the limiting nutrient at all stations in May and at station 1 in October, and nitrogen was limiting at all stations in March and at stations 1 and 2 in October.

C. Nutrient Controllability:

1. Point sources--No known point sources impacted E. V. Spence Reservoir during the sampling year.

The present phosphorus loading of 0.55 g/m^2/yr is more than twice that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). If Vollenweider's eutrophic level is applicable to Texas reservoirs, it is likely that the trophic quality of the reservoir will deteriorate unless the present phosphorus loading is reduced. However, Survey data indicate that all the phosphorus inputs are from non-point sources, and it is questionable whether such inputs can be controlled.

2. Non-point sources--Non-point sources contributed 100% of the phosphorus load to E. V. Spence Reservoir during the sampling year. The Colorado River added 94.0% of the total load, Paint Creek, 0.4%; and the ungaged tributaries were estimated to have contributed 2.4%.

The phosphorus export rates of the Colorado River and Paint Creek were 0.3 and 0.8 kg/km^2/yr, respectively. These rates are quite low compared to the rates of unimpacted tributaries of other reservoirs in the general area.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 25.62 kilometers²;

2. Mean depth: 6.7 meters;

3. Maximum depth: 15.8 meters;

4. Volume: 171,654 x 10^3 m^3;

5. Mean hydraulic retention time: 7.1 years (based on outflow).

B. Tributary and Outlet;
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Colorado River	40,124.3	1.830
Paint Creek	67.6	0.033
Minor tributaries & immediate drainage -	549.1	0.196
Totals	40,741.0	2.059

2. Outlet -

Municipal and irrigation diversion	0.0	0.710††
Colorado River	40,766.6	0.052
Totals	40,766.6**	0.762**

C. Precipitation***;

1. Year of sampling: 63.4 centimeters.

2. Mean annual: 48.3 centimeters.

† Table of metric conversions--Appendix B.
†† Ivie, 1976.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir; lesser outflow due to evaporation (Ivie, op. cit).
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

E. V. Spence Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page vi). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 15.8 meters at station 1, 9.4 meters at station 2, and 6.7 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not preserved properly and were not analyzed).

[illegible] SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR [illegible]
[illegible]

PARAMETER	1ST SAMPLING : [illegible] 1 STATION			2ND SAMPLING : [illegible] 1 STATION			3RD SAMPLING : [illegible] 1 STATION			
	RANGE		MEAN	MEDIAN	RANGE		MEAN	MEDIAN	RANGE		MEAN	MEDIAN
TEMP (C)	11.1	- 34.1	12.4	13.1	21.4	- 23.9	23.2	23.3	24.6	- 25.9	25.3	25.4
DISS OXY (MG/L)	4.6	- 18.4	5.0	4.9	5.2	- 7.8	7.6	7.8	5.8	- 8.0	5.4	6.2
CNDCTVY (MICRO)	1934.	- 1785.	1942.	1785.	2351.	- 2348.	2354.	2347.	2631.	- 2703.	2675.	2663.
PH (STAND UNITS)	6.2	- 6.4	6.2	6.3	8.1	- 8.3	8.2	8.2	7.7	- 8.1	8.0	8.0
TOT ALK (MG/L)	135.	- 154.	140.	140.	133.	- 138.	135.	136.	[illegible]			
TOT P (MG/L)	0.824	- 0.827	0.826	0.827	0.327	- 0.345	0.335	0.335	[illegible]			
ORTHO P (MG/L)	0.884	- 0.888	0.884	0.887	0.385	- 0.391	0.385	0.386	[illegible]			
NO2+NO3 (MG/L)	0.832	- 0.840	0.837	0.838	0.829	- 0.388	0.867	0.875	[illegible]			
AMMONIA (MG/L)	0.821	- 0.840	0.826	0.838	0.838	- 0.338	0.884	0.878	[illegible]			
KJEL N (MG/L)	0.402	- 1.788	0.555	0.488	0.460	- 0.488	0.567	0.588	[illegible]			
INORG N (MG/L)	0.858	- 0.889	0.865	0.840	0.856	- 0.196	0.127	0.845	[illegible]			
TOTAL N (MG/L)	0.448	- 0.738	0.595	0.838	0.428	- 0.886	0.638	0.588	[illegible]			
CHLRPHYL A (UG/L)	4.7	- 5.9	5.3	5.4	3.4	- 6.2	4.7	4.5	12.4	- 15.9	14.2	13.4
SECCHI (METERS)	8.7	- 8.9	8.9	8.8	8.4	- 3.1	8.7	8.7	8.9	- 1.8	1.4	1.4

A SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR [illegible] SPRING RESERVOIR
STUDY CASE #69

FOR SAMPLING [illegible]

PARAMETER	3 STATIONS RANGE	MEAN	MEDIAN
TEMP (C)	17.0 - 25.0	20.7	20.7
DISS OXY (MG/L)	6.0 - 7.6	7.1	7.2
CONDUCTIVITY (MICROMHO)	1203. - 1486.	1324.	1302.
PH (STAND UNITS)	8.2 - 8.5	8.4	8.4
TOT ALK (MG/L)	92. - 107.	104.	105.
TOT P (MG/L)	0.039 - 0.071	0.058	0.060
DISS P (MG/L)	0.009 - 0.023	0.017	0.016
NO2+NO3 (MG/L)	0.023 - 0.259	0.094	0.029
AMMONIA (MG/L)	0.038 - 0.098	0.054	0.045
KJEL N (MG/L)	0.460 - 1.089	0.703	0.700
INORG N (MG/L)	0.371 - 0.288	0.340	0.340
TOTAL N (MG/L)	0.831 - 1.156	0.794	0.729
CHLOPYL A (UG/L)	19.7 - 24.9	22.4	24.8
SECCHI (METERS)	0.6 - 1.1	0.9	0.9

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Algal Units per ml
03/04/74	1. Tetraedron sp.	2,407
	2. Scenedesmus sp.	1,296
	3. Cryptomonas sp.	263
	4. Chromomonas sp.	226
	5. Synedra sp.	188
	Other genera	414
	Total	5,793
08/05/74	1. Oscillatoria sp.	13,345
	2. Raphidiopsis sp.	5,537
	3. Lyngbya sp.	3,691
	4. Dactylococcopsis sp.	2,343
	5. Tetraedron sp.	2,130
	Other genera	2,626
	Total	29,672
10/29/74	1. Oscillatoria sp.	13,268
	2. Dactylococcopsis sp.	6,761
	3. Tetraedron sp.	1,732
	4. Raphidiopsis sp.	887
	5. Oocystis sp.	507
	Other genera	2,958
	Total	26,113

* The May phytoplankton sample was lost in shipment.

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/04/74	1	4.7
	2	5.4
	3	5.9
05/15/74	1	3.4
	2	4.5
	3	6.2
08/05/74	1	12.4
	2	13.4
	3	16.9
10/29/74	1	19.7
	2	24.0
	3	24.8

C. Limiting Nutrient Study:

There was a significant loss of phosphorus in both algal assay samples between time of collection and the beginning of the assays. Therefore, the algal assay results are not representative of conditions in the reservoir at the times the samples were taken (03/04/74 and 10/29/74).

The reservoir data indicate nitrogen limitation at all stations in March and at stations 1 and 2 in October; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 9/1 or less. All stations were limited by phosphorus in May, as was station 3 in October; i.e., the mean N/P ratios were 17 to 1 or greater, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. The outlet and diversion loads were calculated using mean reservoir concentrations at station 1 and the mean annual outlet and diversion flows.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Paint Creek at station B-1 and the mean annual ZZ flow.

No known point sources impacted E. V. Spence Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Colorado River	13,275	94.0
Paint Creek	55	0.4
b. Minor tributaries & immediate drainage (non-paint load) -	340	2.4
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	450	3.2
Total	14,120	100.0

2. Outputs -

Lake outlet - Diversions	670
Colorado River	50
Total	720

3. Net annual P accumulation - 13,400 kg.

* Tyle, 1976.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Colorado River	83,565	70.4
Paint Creek	1,070	0.9
b. Minor tributaries & immediate drainage (non-point load) -	6,365	5.4
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - done	-	-
f. Direct precipitation** -	27,660	23.3
Total	118,660	100.0

2. Outputs -

Lake outlet - Diversions	13,925
Colorado River	1,020
Total	14,945

3. Net annual N accumulation - 103,715 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Colorado River	9.3	2.1
Paint Creek	0.8	15.8

* Tyle, 1976.
** See Working Paper No. 175.

E. Yearly loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	0.55	0.52	4.6	4.0

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of E. V. Spence Reservoir:

"Dangerous" (eutrophic loading)	0.20
"Permissible" (oligotrophic loading)	0.10

V. LITERATURE REVIEWED

Ivie, G. H., 1976. Personal communication (lake morphometry, diversions, and evaporation loss). Colorado River Municipal Water Dist., Big Springs.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible]

LAKE CODE	LAKE NAME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

LAKE DATA TO BE USED IN REGRESSION

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG P	SRP [illegible] UG/L	TKN [illegible]	[illegible] [illegible]	[illegible] [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	4421	[illegible]	239
30	4424	[illegible]	217
31	4425	[illegible]	209
32	4426	[illegible]	205
33	4433	[illegible]	176
34	4435	[illegible]	173
35	4436	[illegible]	164
36	4404	[illegible]	159
37	4411	[illegible]	155
38	4417	[illegible]	136
39	4418	[illegible]	91

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

[illegible]	SUBAREA [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]

TOTAL [illegible] AREA OF LAKE = [illegible]
SUM OF SUBAREAS AREAS = [illegible]

TOTAL FLOW IN = [illegible]
TOTAL FLOW OUT = [illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible] FLOW	[illegible]	FLOW [illegible]	[illegible]	FLOW [illegible]	[illegible]	FLOW
[illegible]	4	74	8.6	6	8.6				
	10	74	8.6	5	8.6				
	11	74	8.6	2	8.6				
	12	74	8.6	9	8.6				
	1	75	8.6	5	8.6				
	2	75	8.6	1	8.6				
	3	75	8.6	2	8.6				
	4	75	8.6	9	8.6	29	34.8		
	5	75	8.6	4	8.6	25	8.6		
	6	75	8.6	22	8.6				
	7	75	8.6	28	8.6				
	8	75	8.6	3	8.6				
[illegible]	9	74	8.382	8	8.837				
	10	74	13.389	5	8.342				
	11	74	4.581	2	4.672				
	12	74	8.595	7	8.623				
	1	75	8.518	5	8.711				
	2	75	8.784	1	8.969				
	3	75	8.257	2	8.364				
	4	75	2.136	6	8.178				
	5	75	5.756	4	8.857				
	6	75	8.519	29	9.178				
	7	75	8.345	28	28.943				
	8	75	5.656	3	7.865				

APPENDIX D

PHYSICAL and CHEMICAL DATA

APPENDIX E

TRIBUTARY DATA